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THE INFLUENCE OF THE VARIATION

OF THE

SIZE OF THE PUPIL

ON THE

ACCOMMODATING POWER OF THE EYE.

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PUPIL OF THE EYE.

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DE LA HIRE and Treviranus thought the accommodation of the eye to different distances depended entirely upon the varying sizes of the pupil, basing their opinions mainly on the well-known fact that the pupil contracts for near objects and dilates for distant ones. Two principal objections have been urged against this theory—first, that were it unconditionally true, then the distinctness of objects should vary in proportion to their amount of illumination, which is not the fact; and secondly, that in viewing two objects (two needles, *e. g.*) through a minute *constant* aperture (a pin-hole in a card), it will be found the eye still exerts its adjusting power, notwithstanding the unvarying size of the artificial pupil we are using. Finding, then, the pupillary movements were inadequate to account for the adjusting power of the eye, physiologists have had recourse to other theories, of which the two principal are the shortening and elongation of the eye by the compressing power of its muscles, and alterations in the curvature and position of the lens by the ciliary muscle. This latter has become, so to say, the theory of the day; indeed, the continental oculists appear hardly to admit any other adjusting power in the eye.

I shall now endeavour briefly to prove that the varying dimensions of the pupil exert a much greater influence in accommodation to different distances, than is generally admitted. It will make the subject more intelligible to assume, in the first instance, that every eye has two extreme limits, within and beyond which perfect accommodation is no longer attainable. The *near* limit is about four to six inches; the *distant* limit extends to the most remote point generally visible by ordinary eyes.* The rays that

* For this simple and practical systematization of the subject, we are mainly indebted to Professor Donders, to whose admirable papers in *Gräfe's Archives*, vol. vi., on the anomalies of refraction and accommodation, I beg to refer my readers.

strike the cornea from remote objects of variable degrees of distance, are all parallel rays, till the object is brought to about two feet from the eye, when they assume a sensible divergence. Thus, practically, the adjusting power of the eye may be said to range between four inches and two feet. Ready as I am to admit, with Volkmann, that within this range of accommodation the size of the pupil appears to assist very little in the adjustment of the eye, I have, by the following experiments, proved that, within the range of distinct vision (about four inches), the pupil exercises a very defined accommodating influence. I took a black pin, and a little below the head scratched a narrow line of the black japan off. I fixed this pin at right angles to an ordinary lucifer match, which I had previously graduated into inches and parts of an inch; then fixed the end of the match perpendicularly into a piece of card, in such a manner that the head of the pin was placed opposite a minute aperture in the card. In this way, by sliding the match backwards and forwards, the pin could be viewed through the artificial pupil (the aperture in the card) at any given distance from the eye. The following tables exhibit the results thus obtained:—

Distance from the eye.	Viewed through the artificial pupil.	Viewed with the naked eye.
¼ inch,.....	Outline of pin tolerably distinct and enlarged; its head quite distinguishable.	Only the faintest linear image; head not at all distinguishable.
½ inch,.....	Pin still more distinct, less in size; head perfectly plain.	Pin still very indistinct; head hardly distinguishable.
1 inch,.....	Pin perfectly distinctly seen; the scratch below the head seen.	Only the middle line of the pin's shank clear; head distinct; scratch not seen at all.
2 inches,.....	Quite distinct.	Pretty distinct; scratch not yet seen.
3 inches,.....	Quite distinct.	Equally distinct; scratch seen.

I then tried the same experiment for reading "Brilliant," (No. 1 type of Jäger's "Sehrift-scalen") with the following results:—

Distance from the eye.	Viewed through the artificial pupil.	Viewed with the naked eye.
¼ inch,.....	Individual letters just perceptible; letters appear enlarged	Lines of type appear only as faint black lines.
½ inch,.....	Individual words readable with difficulty; letters appear enlarged.	Confused lines of type seen.
1 inch,.....	Easily readable; letters enlarged.	Impossible to read at all.
2 inches,.....	Fluently readable; letters enlarged.	Readable with great difficulty.

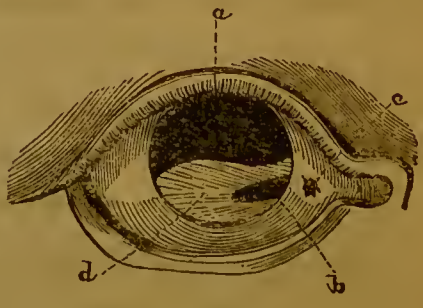
Two facts are thus proved:—
1st, That a pin-hole renders very close objects more distinct.
2nd, That it enlarges the objects.

My own eyes are myopic to an extent that I use concave glasses (No. 4) to read No. 1 type at any distances beyond about eight inches, and for the clear perception of all other more remote objects. I therefore investigated the same facts with a variety of normal, presbyopic and hyperopic eyes. With these I obtained precisely the same results, excepting that the former eyes could not avail themselves of such close distances as I could myself, the latter of still less so, for my experiments. I have further found that no loss of illumination appears to occur in using the pinhole. I shall but allude to the well-known fact, that for ordinary myopic eyes, the artificial pupil exerts a similar effect to that of a concave lens. Another fact in the same direction is, that after the use of atropine, the eye becomes presbyopic, losing its power of accommodation for near objects.*

In further illustration of the adjusting influence of the pupil, I shall now narrate a case which has occurred in my practice:—

Case.—Loss of the entire upper half of the Iris; perfect Loss of useful Vision; its complete Restoration by the use of an Artificial Pupil and a Concave Lens.—Catherine G., aged 41, consulted me at the South London Ophthalmic Hospital, on July 14th of the present year. Four months before, she had struck her right eye against the corner of a table. Inflammation of a very violent character ensued, for which she was cupped and salivated. All inflammatory symptoms are now gone, but she finds she has lost all useful vision in the eye.

On examination, I found the entire upper half of the iris absent; just below the transverse limit of the still remaining lower half of the iris, was inwardly a narrow cross slit—the distorted natural pupil—which had been thus narrowed and drawn inwards by a prolapse of the iris, the healed extremity of which was seen as a black mark on the corresponding part of the sclerotic. The remaining iris was perfectly destitute of contractility. The diagram illustrates the condition of her two pupils.



a Unnatural pupil.
b Distorted and diminished natural pupil.
c Scar of the prolapsed iris.
d Remains of iris.

With the injured eye, on looking at distant objects, she could see nothing but a dense fog. In the window opposite to her (from which she sat about four feet) she could distinguish nothing but the daylight—no bars of the frame. Within a range of about eight to nine inches she could just distinguish the back from the front of the hand, and count the fingers. She could not at any distance

* Weak solutions of atropine paralyse the iris; strong solutions paralyse the ciliary muscle as well.

make out even the single letters of No. 20 of the "Schrift-scalen." On causing her now to look through a goggle provided with an aperture of a little less than one-eighth of an inch, she could distinctly see persons, horses, carts, &c., passing in the street before her, and read No. 19 easily. That these effects did not depend on the diaphragm moderating the excessive illumination through the enlarged pseudo-pupil, was clear from the fact, that variously-tinted dark plane glasses did not in the slightest degree improve her vision. Finding, as mentioned above, that the injured eye possessed a slight amount of useful vision for distances within eight or nine inches, I was induced to add to the goggle a concave lens (No. 6). With this double contrivance, she can now see nearly as well as with the sound eye. She can distinguish the form and colour of articles of dress of persons at a considerable distance from her. She can read with some difficulty No. 6, easily No. 8, and fluently No. 10. But, curiously enough, I found that the lens alone afforded hardly any assistance at all.* On examining the eye with the ophthalmoscope, I could see the optic entrance well; both it and the fundus appeared normal. There was nothing to lead me to suppose any dislocation of the lens had occurred.

Partial or entire loss of the iris appears to be attended with very different results in different cases. In the fourth number of the *Ophthalmic Hospital Reports*, p. 157, Mr. Dixon has reported a case of congenital complete absence of both irides, where vision was, notwithstanding, perfect.†

Dr. Mackenzie has at p. 396, fourth edition of his classical work on the Eye, recorded a case of injury, in which all "that remained of the iris was a narrow floating shred. The lens was opaque, . . . yet with this eye the patient discerned fingers;" and he remarks—"In such cases the eye, though generally quite amaurotic, is highly intolerant of light, and must be covered with a shade."

We have thus seen that the pinhole corrects malposition of the focus of too divergent rays in all classes of eyes, hyperopia, presbyopia and myopia.‡ These conditions have all one fact in common, viz., that the focus is *displaced* (either behind or before the retina). The consequence is that all the luminous points of an object are expanded into circles on the retina, giving rise to indistinctness

* The plan of treatment I adopted in this case is the same as that recommended by Mr. Wharton Jones, at p. 319 of the first edition of his work on the Eye.

† In a second case of Mr. Dixon's of coloboma iridis (*Ophthalmic Hospital Reports*, No. 3, p. 109)—much more extensive than in our case—the patient "could read the small type of an advertisement in the *Times*."

‡ In hyperopia and presbyopia, the rays are too divergent for the eye before they reach it. In myopia they become so after passing their focus within the eye, anterior to the retina.

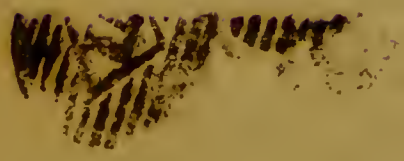
of vision. The effect of the pinhole is not to replace the focus to its proper position, the retina; not to correct spherical aberration of the lens; not to moderate excessive illumination. For the first purpose it is inadequate; for the two latter it is unnecessary. Its effect is to cut off the outer rays of the pencils of light. Thus, the "circles of confusion" on the retina are reduced in size. Each luminous point is still expanded into a circle on the retina, but into one so minute, as to render the image produced by the joint assemblage of the circles quite distinct. We can now understand how it is that objects viewed through pinholes appear *enlarged*.* Each point of the object is magnified into a circle. In the case of traumatic coloboma iridis, I have reported, the ciliary muscle may have been perhaps so injured, as to have interfered with the natural adjustments of the lens. It is at any rate worthy of remark, that, as a rule, congenital irideremia is attended with less derangement of vision than that resulting from injuries to the eye.

In the tenth number of the *Ophthalmic Hospital Reports*, Dr. Wells mentions a case of Von Gräfe's, in which, after removal of the entire iris the patient could read No. 1, retained *almost* perfect accommodation, and was not in the least dazzled by the light. After the application of atropine, accommodation was entirely destroyed through paralysis of the ciliary muscle. In this case, then, the pupil appeared to exert very little influence on accommodation. Dr. Wells does not inform us, whether the effect of a diaphragm was tried. I have, through the kindness of the surgeons at that great school of ocular surgery, the Moorfields Ophthalmic Hospital, been enabled to study several cases of absence of the lens (the result of operation) with integrity of the pupil. In the majority of these cases the patients have been enabled to accommodate their vision to different distances by bringing the two eyelids into such close apposition, as to leave but a narrow linear aperture between them—an artificial pupil, in fact. If in such cases the eyelids be held open, and the patients be told to look through a pinhole in a card, the same effects will ensue as from their own instinctive approximation of the eyelids. As before alluded to, a strong solution of atropine (about one part to 120 of water) destroys the adjusting power of the eye for divergent rays. I find that a pinhole aperture considerably restores it. I have further found that patients can, with the addition of a pinhole diaphragm added to their glasses, do with powers several numbers lower than without the diaphragm. This method has two objections—firstly, such spectacles look rather strange on a person; secondly, the field of view is somewhat diminished thereby. On the other hand, many cases of

* This I have found invariably to be the case in all the persons I have examined.

extreme defective adjusting power are met with in practice, in which, especially if associated with much irritability of the eye, the diaphragm will be found useful. Mr. Critchett has, in his paper on his admirable operation of "Iriddesis," fully recognised the importance of the pupillary functions, laying considerable stress on the preservation of the circular fibres of the iris, by which "the defined edge and the natural contractility of the normal pupil is secured."*

* Vide Ophthalmic Hospital Reports, No. V.—"Iriddesis; or the Formation of Artificial Pupil by tying the Iris." By Mr. Crichett.



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